DEMAND ASSESSMENT AND THE SUPPLY/DEMAND BALANCE

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Summary

A good understanding of the factors influencing water demand and a reliable water demand forecast are prerequisites for water resources planning. The methods used for forecasting demand and the level of sophistication will depend on the end use and the available data.

Deriving a demand forecast that is appropriate for the intended use is commonly a five

stage process.

(a) Stage 1. An analysis of historical records to determine and quantify the components of demand.
(b) Stage 2. Development of forecasts of future demand for each component of demand.
(c) Stage 3. Summation of the component demand forecasts to derive a total demand forecast.
(d) Stage 4. Testing the sensitivity of the forecast to different component forecast assumptions.
(e) Stage 5. Forecasting peak demands which are appropriate for the intended use.

Where tariff changes are proposed to fund water resource developments and/or to control demand, a sixth stage is required to examine the sensitivity of the demand forecast to changes in the price of water.

This chapter describes the techniques commonly used to assess demand following the stages outlined above. It also describes how the demand forecast is used to assess water resource requirements and the risks associated with the supply/demand balance, including outage and headroom.

1. Introduction

Any form of planning for a water supply system starts with a water demand forecast. The methods used for forecasting demand and the level of sophistication will depend on the end use, the available data, and auditing procedures. In countries where water supply authorities are regulated or their investment decisions are open to public scrutiny, the methods used for demand forecasting must be transparent.

Demand forecasts are used for strategic planning, investment appraisal, and operational planning. The requirements for each overlap but are generally different, influencing the techniques applied.

Strategic planning: A long-term regional forecast is required for water resources planning, land allocation, financial capital planning, tariff setting, and revenue prediction. The planning horizon is usually of the order of 20-50 years (depending on the time-scale of the planned investment) and a range of forecasts is made to test the sensitivity of policy decisions on certain forecasting assumptions.

Investment appraisal: A medium- to long-term forecast is required which is specific to the project area to assess investment alternatives. Various techniques are used to derive the area forecast from the regional forecast to ensure overall compatibility. The impact of different forecasting assumptions on investment decisions, including demand management options, are usually assessed at this stage.

Operational Planning: Operational planning requires short-term demand forecasts for activities such as network analysis, pump scheduling, and system control. The forecasts must predict demand variations on an hourly basis, taking account of the varying diurnal demand patterns of different consumers, season, weather, and holiday periods. The predictive methods used are quite different to medium- and long-term forecasting techniques and are outside the scope of this chapter.

The internationally accepted practice for water demand forecasting is component analysis, that is developing a total demand forecast by combining separate demand forecasts for different components of demand. This recognizes that different components of demand vary at different rates and are influenced by different factors. Trend extrapolation forecasts on total water demand, which were commonly used in the UK in the 1960s, have been discredited for the potentially large errors that they can introduce. For example, the following.

(a) Not recognizing the different growth characteristics of domestic and industrial demand.
(b) Not separating leakage demand from other types of demand, resulting in leakage being predicted to grow at the same rate as population and per capita consumption.
(c) Assuming that per capita consumption grows continuously and never slackens or reaches saturation.

There are generally five stages to preparing a water demand forecast by component analysis.
(a) Stage 1. An analysis of historical water production and consumption records to determine and quantify the components of demand. This is discussed in Section 2.
(b) Stage 2. Development of forecasts of future demand for each component of demand. This is discussed in Section 3.
(c) Stage 3. Determination of the total demand forecast by summation of the component demand forecasts.
(d) Stage 4. Testing the sensitivity of the forecast to different component forecast assumptions. This is discussed in Section 4.
(e) Stage 5. Forecasting peak demands which are appropriate for the intended use. This is discussed in Section 5

In addition, it is also common to assess the impact of price on the demand for water. Tariffs and elasticity of demand are discussed in Section 6.

2. Present Water Balance

2.1. Components of Demand

Before a forecast can be made, the different components of demand must be identified and quantified for a selected base year (normally taken as the most recent year for which a complete set of records exist). Where demand is not constrained, this can form a basis for predicting future demand.

It is important to identify where water goes from source to end use. A typical breakdown of the components of demand is shown in Figure 1, using definitions which are consistent with international practice. It shows where water losses are likely to occur in a water supply system and where flow data may be misleading. The operational use shown as part of raw water supply to treatment includes net process water and on-site domestic use and the treated water losses allow for any leakage or overflows from tanks. The operational use shown as part of the distribution input is for pipe flushing, fire-fighting, street watering and unmetered water used in public parks.

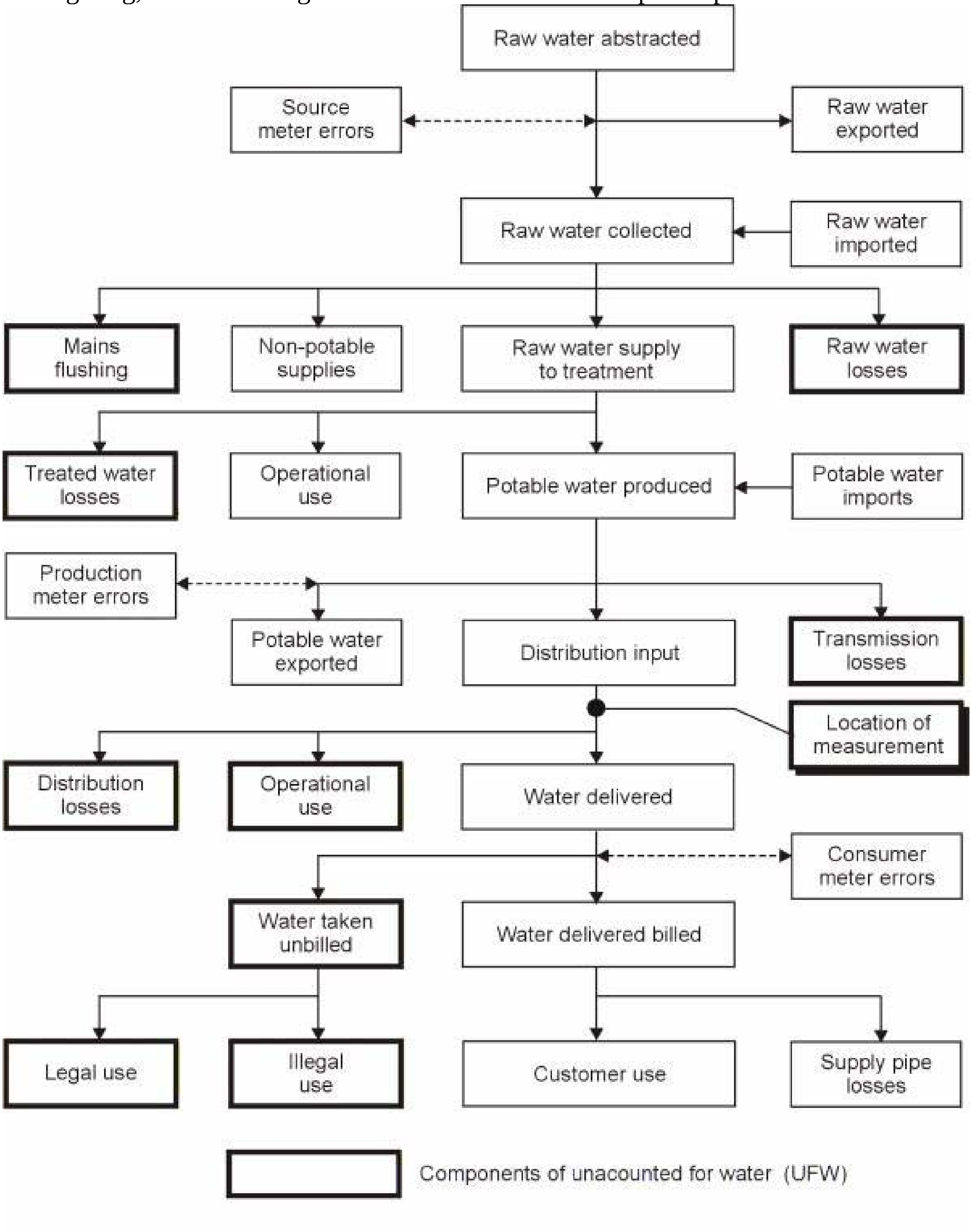

Figure 1. Water demand components.

The components of unaccounted for water are highlighted in Figure 1. Unaccounted for water is the difference between the total quantity of water put into supply (raw or treated) and the total measured or billed consumption. Unaccounted for water is discussed in Section 2.9. In most countries, water supplies are metered and the major

part of water delivered billed is therefore measured. This is not the case in the UK and a few other countries where most household use is unmeasured.
It is normal to divide customer use into different categories of demand as their patterns of use and demand growths differ and are affected by different factors. The following categories are typical.

(a) Domestic household use.
(b) Commercial use (shops, offices, hotels, and restaurants).
(c) Industrial use (factories, industries, and ports).
(d) Agricultural use (farmhouses, livestock, horticulture, greenhouses, and dairies).
(e) Institutional use (hospitals, schools, government offices, and military establishments).

It is important to define the location of measurement for which the demand forecast applies. This is commonly taken as immediately upstream of the distribution system (as shown in Figure 1). This follows the traditional distinction made in the water industry between "supply" and "distribution". If the demand forecast is to be used for water resources planning, however, then the upstream components of demand need to be added to the forecast. This needs to be done in a manner consistent with the methods used for assessing the deployable output of the sources. For example, treatment process water included in operational use is often taken as a constraint on deployable output rather than a demand.

The methods used for quantifying each component of demand will vary with data availability.

2.2. Sources of Data

Common sources of data for assessing the present water balance are listed below.

(a) Water production data.
(b) Billing records with recorded consumption data.
(c) Distribution zone flow data.
(d) Leakage control zone flow data.
(e) Records of bulk imports and bulk exports of raw or treated water.
(f) Leakage measurements and/or minimum night flow records.
(g) Process water use at treatment works.

Consumer billing records are potentially the most useful source of data. They contain information on the following items.

(a) Average consumption per property between meter readings (generally 1-6 months).
(b) The consumer category (domestic, commercial, and industrial).
(c) The meter block number and/or meter book number or other geographical reference.

From this information, it is not only possible to quantify consumption by different types of consumer but their geographical location is known as well. This means that the geographical distribution of demand can be accurately determined, which is important for deriving area forecasts for water balance modeling to determine local resource requirements. It may be necessary to summate several sets of billing records to establish annual average consumption figures and the quantities of data may be considerable, particularly in large distribution systems. A database often needs to be created to store the relevant data from the billing records and to summate consumption by consumer category. It is important to check that the data is complete for all areas, that the number of estimated meter readings is relatively small and that meter accuracy is reasonable, (see below).

Distribution zone flow data or leakage control zone flow data can also be used to estimate the geographical spread of demand, though it is difficult to estimate the proportions of demand attributable to different types of consumer without billing data.

2.3. Meter Accuracy

Before accepting water production data as a measure of total demand, it is important to check that all the production flow meters are working correctly and have been recently calibrated. Most modern water supply systems use electromagnetic flow meters and these usually have exceptionally good accuracy (±0.5 per cent over a wide range) provided that they are properly sited and set up. The accuracy of older types of flow meter such as inferential meters, Dall tubes, or Venturi meters may be suspect and it is advisable to carry out checks by installing insertion flow meters downstream or checking the flow measurements against other flow or tank level data.

Consumer meters may also be inaccurate or in many cases inoperable, rendering the billing data suspect. A visual inspection of the billing data may reveal a large number of "estimated" readings and field inspections may confirm a large number of stopped or unreadable meters. Consumer meters should be routinely tested and repaired every 5 years or so and, where this does not occur, significant under-recording of consumption must be suspected. Tests undertaken in the UK by the Water Resources Center (WRC) in 1984 showed average meter under-registration to be 2.5 per cent and 6 per cent for direct and indirect supply systems, respectively. Larger under-registrations are likely for poorly maintained meters or where the meter is inappropriately sized or of the wrong type.

Where it is suspected that meter under-registration may significantly affect the consumption recorded, tests should be undertaken to try to quantify it. This requires the use of a meter testing facility to test a sample of consumer meters and the installation of high-accuracy meters at a selection of households to test meter performance under local distribution system conditions. The results from these tests can be used to estimate overall meter under-registration which can be allocated to the components of customer use such as domestic and non-domestic demand.

2.4. Constrained Supplies

In many countries, water supplies are restricted and the consumption data held by water companies do not necessarily reflect the true demand for water. The following factors constrain water demand.

(a) Customers receive either a very low-pressure supply or an intermittent supply.
(b) Significant proportions of the population are not connected to the public water supply system.
(c) Few people have access to waterborne sanitation, limiting the amount of water used for toilet flushing.
(d) Significant proportions of the population rely on public standpipes.
(e) High levels of leakage or consumer wastage results in unsatisfied demand in parts of the water supply system.

Sometimes, the total quantity of water put into supply may seem adequate on an average per capita basis, but high levels of leakage in the centre of a city, for example, may deprive the suburbs of adequate supplies of water. In these circumstances, the billed consumption records will not reflect true demand.

If new infrastructure is proposed which would allow such restrictions to be lifted, then the presumption that the present water balance is a good basis for future demand forecasting will not be valid. In such circumstances, estimates of unconstrained demand must be made, either from data obtained for any limited parts of the water supply system which receive a 24 h supply or from data for similar nearby communities. Consumption surveys provide the best basis for estimating unconstrained demand.

2.5. Consumption Surveys

Consumption surveys can provide direct measurements of unconstrained consumption for different categories of consumer where billing data is suspect, incomplete, or absent for a significant proportion of demand. A simple survey might involve the following steps.

(a) Classify domestic dwellings into five or six classes and test meter 25-30 dwellings from each class in a part of the network which receives a 24 h supply. Derive the average per capita consumption per class according to the number of occupants.
(b) Test meter standpipes, where standpipe supplies are a significant component of demand and, by estimating the population reliant on them, determine the average per capita consumption.
(c) Check the accuracy and read the supply meters for the largest non-domestic and agricultural consumers. Generally in urban areas, it can be found that over 70 per cent of the non-domestic consumption arises from fewer than 10 per cent of the consumers. Thus, a limited survey of the largest consumers can provide information on the bulk of the non-domestic demand. Whilst visiting these industrial premises, other information on weekly working patterns, private water sources, and future water supply requirements can be obtained.
(d) Test meter a selection of unmetered or free supplies to government buildings and elsewhere where it is suspected that significant consumption takes place. Consumption from military establishments can be particularly high.
(e) Estimate total demand using the data obtained from the foregoing investigations and plans with areas of different classes of dwelling marked on and measured. An allowance for distribution leakage should be included in the total demand estimate.

The difficulty with a one-off survey of the type described above is that it provides limited detail and only gives a snapshot picture of demand. For a more detailed picture and to identify changes in water using habits, continuous consumption monitors are required, where metered data from samples of households of different categories are collected over a period of years. This requires significant investment by a water authority to install the necessary meters and to collect and analyse the data continuously, but the data is invaluable in obtaining a better understanding of water consumption and the factors influencing it. It is also essential for planning water conservation measures (see Section 3.5).

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